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Guidance for Large Wind Energy Conversion System Noise Study Protocol and Report



Guidance for Developing and e-Filing the LWECS Noise Study Protocol and Report Submittals to the Minnesota Public Utilities Commission

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to reflect the current phone number above.*

Minnesota Department of Commerce,
Energy Facilities Permitting
October 8, 2012

Acknowledgments

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Guidance for Developing and e-Filing an LWECS Noise Study Protocol and Report

Purpose

The purpose of this guidance document is to aid wind developers in the preparation and use of a noise study protocol that standardizes sound monitoring methodologies, analysis, and presentation. The purpose of the protocol and the resulting noise study report are to quantify sound generated by an operational Large Wind Energy Conversion System (LWECS) at receptors: sound that is present during the measurement, project-related and otherwise. This monitoring will provide information to:

- (1) confirm the validity of the noise modeling conducted prior to permit issuance or prior to construction;
- (2) assess the modeling as a predictor of probable compliance with Minnesota noise standards; and
- (3) determine the noise levels at different frequencies and at various distances from the turbines at various wind directions and speeds.

This document provides guidance for developing a noise study protocol. The actual protocol for a specific project may be more detailed and shall address project-specific considerations.

Noise study protocols are reviewed by Department of Commerce, Energy Facility Permitting (EFP) staff, and staff comments and recommendations are provided to the Minnesota Public Utilities Commission (Commission). EFP staff may recommend and the Commission may require changes to a noise study protocol. Consult with the EFP staff state permit manager for the project when preparing the noise study protocol and report.

Monitoring Conditions

1. **Monitoring Within the Project, Same Locations, Turbines On, Turbines Off.** Using the same methods and the same monitoring locations within the project site, monitor sound during events described in 1.a. and 1.b. below:
 - a. with this project's turbines not yet constructed or not operating :
 - i. during selection of turbine layout before any construction OR
 - ii. later, with all of this project's turbines in place but not operating, either before or after operation; AND
 - b. during operation, with this project's turbines operating.
2. **Monitoring Off-Site, Same Timeframe.** In addition, concurrently with the monitoring in 1.b., conduct off-site monitoring to contribute additional data that supports evaluation of sound that exists in analogous environments in the absence of wind turbines, in the same timeframe. For comparability, noise monitoring methodology for off-site monitoring must be the same as for the monitoring in 1.b.

3. **Results from Monitoring Without Turbines Present or Operating.** By either approach in 1.a. and 2., noise monitoring results without turbines present or operating and for off-site location(s) will be used, depending on purpose, along with the measure of total noise that exists during turbine operation, as described in Minnesota Pollution Control Agency (MPCA) comments attached as Appendix A.
4. **Data Sets.** Datasets must be maintained for monitoring at all wind speeds with and without turbines in place or operating and for off-site locations. Note that for any purpose relating to the Minnesota noise standard, MPCA requests the removal of noise data where windspeeds at microphone height (at least 3 feet above the surface) are greater than 11 miles per hour. Likewise, MPCA requests the removal of noise data during periods of precipitation. See MPCA comments in the Appendix and items 17 and 29 below.
5. **Seasonal Timing.** Monitoring that is conducted for each monitoring event described in 1.a., 1.b. and 2. must be conducted in the same seasonal time period, in order to avoid differences in the landscape and other seasonal weather-related factors. If the monitoring is conducted in two different years, the starting date of the most recent monitoring event must be within approximately two weeks of the anniversary starting date of the other, either before or after. If the monitoring for 1.a. or 1.b. is conducted in the same year, the starting dates must be approximately two weeks apart.

Explain the choice of season and the factors that were considered.

6. **All Turbines Operating.** Determine actual sound levels during operation of the LWECS with all turbines operating because this was an assumption in the modeling. Data must be included in the reports for the monitoring to document the operation for each turbine during the measurement period.

Monitoring Locations

7. The protocol must include a clear rationale of the selection of the locations where sound will be monitored, whether within the project or off-site. The rationale should characterize the location regarding the features it was selected to represent and its distance to receptors and to nearby turbines or other sources of sound.
8. A minimum of three locations within the project area, for each monitoring event described in 1.a. and 1.b. of this section, must be identified for sound monitoring at locations that are representative of the project area and in proximity to a receptor, such as a residence. The same locations must be monitored during each of the monitoring events. The locations must be at different distances to a turbine or turbines.
9. For off-site monitoring that is done, a rationale for the selection of off-site monitoring locations must be provided including factors that were considered in determining that the environment at these locations is analogous to the locations within the project site.
10. Larger project areas may require additional monitoring locations. Discuss the monitoring locations with the Department of Commerce Energy Facility Permit Manager as early as possible.

11. One monitoring location must be in proximity to the worst- case receptor predicted by the model.
12. Monitoring locations that are in areas that reflect or absorb sound or where there are obstructions to sound must not be selected.
13. Monitoring locations for sources of sound such as factories, feedlots, agricultural outbuildings and highways for relative impact analysis may be done separately for that purpose, but this monitoring is not expected for the purpose of the noise study described at the beginning of this guidance.

Monitoring Duration

14. For monitoring described in 1.a., 1.b., and 2., collect sound measurements continuously over a minimum of a 7 to 14 day period. Include in the protocol an explanation of the criteria that will be used to determine if the monitoring timeframe will be extended; for example, if insufficient data of a certain type is not obtained.

Monitoring Wind Speeds

15. Report continuous sound measurements at all wind speeds that occur during the minimum 7 to 14 day monitoring duration. Monitor and report wind speed at hub height and, at each monitoring location, at microphone height.
16. Monitoring that is conducted for 1.b. must adequately demonstrate sound at each location for wind speeds above the identified cut-in wind speed for the turbine model or the monitoring duration should be extended.
17. To meet protocol requirements for comparison to MPCA noise standards, the monitoring described in 1.b. must adequately demonstrate sound at each monitoring location at wind speeds less than 11 miles per hour measured at microphone height (at least 3 feet above the ground). This is to provide sufficient data below the point at which wind distortion may occur.

Instruments

18. Use a sound level meter and a microphone conforming to type 0, 1, 2 or S specifications under ANSI S1.4-1983, a calibrator of known frequency and level, and an oversized microphone wind screen.

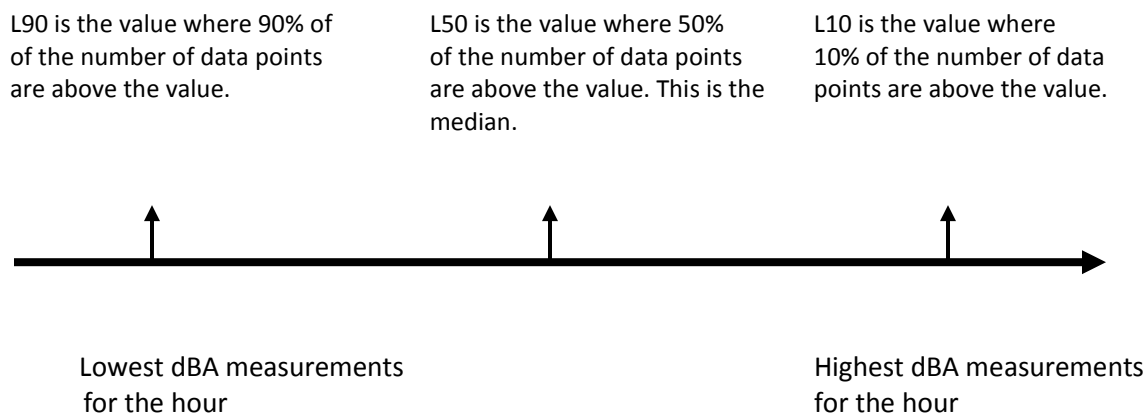
The use of continuous sound level measurement devices is encouraged along with qualitative sound recordings to identify sources of “spikes” in sound unrelated to the LWECS, such as a car going by or a dog barking.

An anemometer or similar instrumentation to determine wind speed at microphone height must be used.

Methodology

19. Calibration must be done before and after the monitoring period. Sound measurements must be taken at least 3 feet above the ground.
20. For monitoring in 1.a., 1.b. and 2., determine unweighted sound; A-weighted dBA as L10, L50, L90 and Leq on an hourly basis; and C-weighted L10, L50, L90 and Leq on an hourly basis. Each one hour period must begin at the start of the hour in the recorded time of day. See Figure 1. In the final report define these terms to avoid confusion.

Figure 1.



21. For monitoring in 1.a., 1.b. and 2., determine unweighted, A-weighted and C-weighted one-third octave-band analysis for at least as low as 16 (preferably lower), 20, 25, 31.5, 40, 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1K, 1.25K, 1.6 K, 2K, 2.5K, 3.15 K, 4K, 5 K, 6.3 K, and 8K HZ or higher for a representative wind speed for the location that is in proximity to the worst-case receptor predicted by the model and for the off-site location.
22. Meteorological data from one or more met towers within the project must be obtained for the same time periods as the time of measurement for the monitoring locations and at the same intervals.

Processing the Data: describe in the protocol how data will be processed

23. For each monitoring location and for each monitoring event described in 1.a., 1.b. and 2., indicate in the report how many data points were collected in each hour and the interval between measurements.
24. "Spikes" of sporadic noise, such as a motorized vehicle going by, a clap of thunder, or a dog barking, may be eliminated from the data, as long as an explanation is included in the report for the types of sound

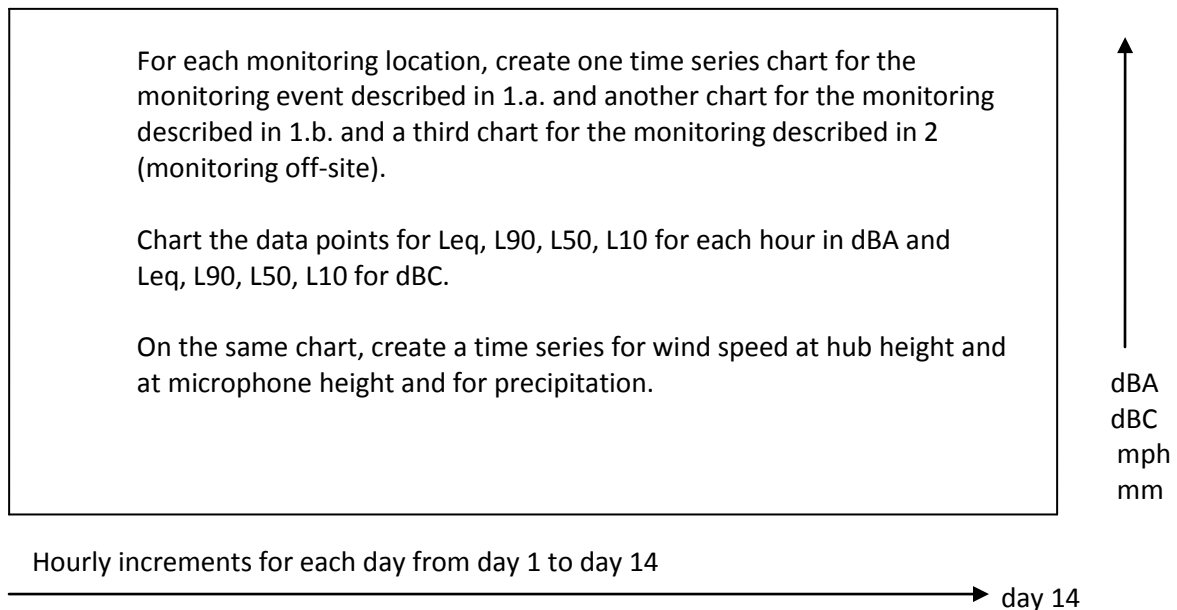
and percentage of measurements for each that were eliminated, for each location and for each monitoring event described in 1.a., 1.b. and 2. Similarly, data collected during documented periods of precipitation may also be eliminated from the data, as long as an explanation is provided in the report and the percentage of measurements that were eliminated, for each location and for each monitoring event, is reported.

25. For the monitoring in 1.a., 1.b., and 2., for each hour, for all the sound measurements obtained during that hour, determine the L10, L50, L90, and Leq as dBA and the L10, L50, L90 and Leq as dBC. Do not include the sound measurements that are being eliminated with explanation as allowed in 24 above.

Results and Charts: in the protocol, describe the charts and how results will be presented

26. **Results at Varying Wind Speeds.** Chart a time series of the Leq, L90, L50 and L10 for dBA and Leq, L90, L50 and L10 for dBC sound levels for each hour. Chart a similar time series (combine them onto one chart with the sound levels) for corresponding wind speed in miles per hour and precipitation in mm. If the number of parameters presented on the chart is crowded, separate charts may be done for the sound level parameters if preferred but wind speed and precipitation should always be shown along with a measure of sound level.

Figure 2. Presentation of Results for all data for monitoring in 1.a., 1.b., and 2.



27. **Results at Varying Frequencies.** For the location that is in proximity to the worst-case receptor predicted by the model for the monitoring in 1.a. and 1.b. and for the off-site location for the monitoring in 2., report one-third octave-band analysis (at least as low as 16 and preferably lower, 20, 25, 31.5, 40, 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1K, 1.25K, 1.6 K, 2K, 2.5K, 3.15 K, 4K, 5 K, 6.3 K, and 8K HZ or higher). Chart the results for a representative wind speed in two ways:
- Compare unweighted sound measurements over the range of frequencies for the worst-case receptor for 1.b. with turbines operating to the unweighted sound measurements for 1.a. and for 2.
 - Compare unweighted sound measurements, A-weighted sound measurements and C-weighted sound measurements over the range of frequencies for the worst-case receptor location for 1.a. and 1.b. and for 2. A separate chart may be used for each location.
28. **Document Varying Wind Directions and Other Meteorological Conditions.** All meteorological data from one or more met towers within the project must be obtained for the same time periods as the time of measurement of the monitoring locations and at the same intervals. This data should be used in the report to document the range of wind and atmospheric conditions during the testing that may be helpful to interpreting the results.
29. **Comparison to Minnesota Noise Standards.** For the data sets containing only sound levels for wind speeds less than 11 mph, create the same chart described in item 26 above for hourly L10 and L50 in dBA and highlight any hourly L10 and L50 determinations that are above the daytime or nighttime Minnesota noise standards.
30. **Map Location of Monitoring Points.** In the report for each monitoring event described in 1.a., 1.b. and 2., provide a map showing an aerial photographic layer with the location of turbines, monitoring locations, residences and location of significant local sound sources such as concentrations of agricultural activity (for example, a feedlot) or human activity (for example, traffic). The scale of the map should show the distance between monitoring points and the distance of the monitoring point to the nearest turbine.
31. **Results of Noise Modeling.** Present a map of the modeling that was done previously for the project. Modeling contours must be represented on the map as lines, or transparent shading, at 5 db increments. Show the contours for modeling provided with the permit application, adjusted for the final turbine layout prior to construction. Explain what the contours represent precisely.

For modeled sound predicted during the permitting process or prior to construction, include in the report an explanation of the methodology, the assumptions in the chosen model and a narrative description of the choices made for criteria in using the model.

Conclusions

32. Indicate in the protocol that the following will be included in the final report on the noise study:
- a. A narrative conclusion regarding how well the results compare to the predicted sound levels for the project. If the results do not compare favorably, explain.
 - b. A summary of the L10 and L50 hourly determinations that are above the Minnesota noise standards for each monitoring location.
 - c. A narrative conclusion regarding how well the results provide information regarding the modeling as a predictor of probable compliance with the Minnesota noise standards. If the results do not compare favorably, explain.

Noise Study Protocol

33. E-file the noise study protocol for the monitoring to be done for 1.a., 1.b., and 2.
34. The noise study protocol for the monitoring in 1.a., 1.b. and 2. should describe:
- a. the purpose of the monitoring;
 - b. the monitoring conditions;
 - c. the monitoring locations and their rationale;
 - d. the monitoring duration;
 - e. the monitoring for wind speeds and other weather conditions;
 - f. the instrumentation, its manufacturer and model, as well as the equipment;
 - g. the procedures in this guidance;
 - h. the methodology in detail and its assumptions;
 - i. data processing including the data that is allowed to be eliminated with explanation;
 - j. the data that will be included in the report;
 - k. how the data will be analyzed;
 - l. how results will be presented;
 - m. any project-specific detail necessary to expand on the protocol; and
 - n. documentation of any environmental condition differences from pre-construction or turbines-off monitoring that was done with explanation.

Noise Study Report

35. E-file the noise study report for the completed monitoring and a cover letter summarizing the results and conclusions. In the noise study report, describe the actual conditions, measurement locations, instrumentation, procedures, methodology, data obtained and results, including charts, and conclusions. Document any changes from the approved protocol with an explanation as to the necessity, and any impact the changes may have on interpretation of results.

Attach the previously e-filed protocol for the monitoring to the noise study report. Indicate in the report any approvals of the protocol by the Minnesota Public Utilities Commission and how and when the approvals were obtained.

36. Finally, taking into account MPCA's comments included below in Appendix A, provide a narrative analysis and conclusion regarding how the results validate or do not validate the pre-construction sound modeling; the usefulness of the modeling as a predictor of probable compliance with Minnesota noise standards; and any identified hourly determinations of the L10 and L50 that are above the Minnesota noise standards.

E-Filing

37. After the Noise Study Protocol or Noise Study Report has been prepared according to this guidance, complete a compliance filing on the Minnesota Public Utilities Commission (Commission) and Department of Commerce E-Dockets system, by the date specified in the Commission LWECS site permit for the project, at this web address: <https://www.edockets.state.mn.us/EFiling/>.

Address the cover letter to the Executive Secretary of the Minnesota Public Utilities Commission for the submittal and for any subsequent revisions.

Dr. Burl W. Haar
Executive Secretary
Minnesota Public Utilities Commission
350 Metro Square Building
121 Seventh Place East
Saint Paul, MN 55101

Please note that if a specific Minnesota Public Utilities Commission LWECS site permit condition is inconsistent with this guidance, language in the Commission LWECS site permit takes precedent.

Appendix A

October 8, 2012

MPCA Comments on the draft DOC/EFP Guidance for LWECS Noise Study Protocol

One of the purposes of EFP guidance document is to “assess the modeling as a predictor of probable compliance with Minnesota noise standards”. Related to this is the need to “confirm the validity of the noise modeling...” These comments are related to the use of data for measuring compliance of noise from wind turbines with Minnesota Rules chapter 7030.

Monitoring conditions

Conducting noise monitoring on-site (without turbines in operation and with turbines operating) or combining monitoring on-site with off-site monitoring both address the issue of identifying and measuring background noise. This is important for both model validation and for rule compliance. The question of whether to subtract or not subtract background noise depends on the situation. The treatment of background noise measurement depends on the application of the data.

a) *Modeling.* Developers should not propose projects where total noise is estimated to exceed the noise standards at receptor property. Modeling wind farms before construction should include total noise-- turbine noise and background noise as datasets. Then the total monitored noise can be compared to the total modeled noise. If only turbine noise were modeled, then monitored background noise must be applied to adjust the measured noise in order to compare the noise from turbines to the modeled estimates. The monitored noise values are used to compare to the model estimates. They are also used to measure compliance.

b) *Compliance.* Although the noise rules apply to total noise measured at a wind farm, the culpability of the wind turbines depends on attribution. If noise exceedances are recorded, it is necessary to determine the increment due to the turbine noise. Background noise information is very important to this effort. This is where background data might be “subtracted”. Compliance is based on the inclusion of background in total noise, whereas attribution depends on the use of the background information to adjust the measured noise to the source (turbines).

In all cases, the separate datasets should be retained. Future applications of the data for compliance determination may require the use of all three--- total, turbine only, and background. The integrity of separate background measurements is also important for communicating with residents (or other receptors) about the noise from the wind farm and the addition (large or small) to the pre-existing non-turbine noise.

Monitoring wind speeds

The issue of wind speed at the monitor bears directly on the compliance issue. It is appropriate to flag and remove noise data where surface wind speeds at the monitor were greater than 11 mph. In like manner, noise data during rainfall should also be excluded. Each of these events is identified with meteorological data. Impulsive noise and other spurious artifacts in the datasets, identified with audio recordings, should be removed before analysis of the data against the noise standards. The L10 and L50 noise standards are correctly stated with a corresponding one hour time interval.

Gordon Andersson
MPCA/EAO

Appendix B

References

1. American Wind Energy Association and Canadian Wind Energy Association, *Wind Turbine Sound and Health Effects*, An Expert Panel Review, December 2009
2. Minnesota Department of Health, Environmental Health Division, *Public Health Impacts of Wind Turbines*, May 22, 2009
3. Minnesota Pollution Control Agency, *A Guide to Noise Control in Minnesota*, 2008
4. National Association of Regulatory Utility Commissioners, *Wind Energy & Wind Park Siting and Zoning Best Practices and Guidance for States*, January 2012.
5. National Association of Regulatory Utility Commissioners, *Assessing Sound Emissions from Proposed Wind Farms and Measuring the Performance of Completed Projects*, October 2011
6. Wisconsin Public Service Commission, *Measurement Protocol for Sound and Vibration Assessment of Proposed and Existing Wind Electric Generation*, adopted May 26, 2010